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ABSTRACT

To account for observed sex differences on tasks such as the rod and frame test, the embedded figures test, and other related measures, the theory is advanced that a sex-linked recessive gene mediates or facilitates certain performances. This assumption is coupled with the concept of "a mixture of density functions" to provide a theoretical account of the continuity of observed performance scores, increases in magnitude of sex differences with development, and certain anomalies in cross-cultural data. The theory generates predictions concerning the shapes of the distributions of observed scores and the manner in which parameters of these distributions, for each sex, should be ordered. As an example of how these assumptions can be applied, rod and frame data from a previous study are fitted to the theory. Results are found to be in good agreement with theoretical predictions. (Author/RH)

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(a) A Strong Theory of Psychological Differentiation

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(d) Suppose that the observed sex differences on tasks such as the rod and frame are mediated, in part, by a sex-linked gene. Coupling this hypothesis with the simple notion of a mixture of density functions allows for the development of a theory which accounts for the continuity of observed performance scores, the increases in magnitudes of sex differences with development, and certain anomalies in cross-cultural data as well. The theory generates predictions concerning the shapes of the distributions of observed scores and how the parameters of these distributions, for each sex, should be ordered. As an example of the application of the theory, rod and frame data from Oltman (1968) and Witkin et al. (1954) are fit to the theory. The results are in good agreement with theoretical predictions.

(e) 20 minutes requested, if possible. Delivery would be facilitated by availability of an overhead projector.

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A Strong Theory of Psychological Differentiation

For decades researchers have been testing children and adults on various Witkin tasks such as the rod and frame (RF) and embedded figures test. Certain consistent findings emerge from many studies (Witkin & Goodenough, 1981; Witkin & Berry, 1975): i) Within cultures if there are sex differences in performance, performance favors boys; ii) the manifestation of reliable sex differences may not be evident until later in adolescence; iii) in some cultures sex differences are striking, while in other cultures, e.g., those Witkin and Berry (1975) have characterized as hunting cultures, such differences are often absent.

Usually theoretical interpretations of these findings have focused on cultural or socialization influences, although the possibility that biological factors may play a role has not been denied at least by Witkin and Goodenough (1981). Still, there exists no unified theory which can account for all these differences. The proposed theory does provide such a framework; it is a strong theory, because it makes falsifiable predictions, and in some cases makes point predictions about the nature of parameter values.

While not denying the role of socialization factors, the theory assumes that an X-linked gene mediates or facilitates certain performances; specifically, it is assumed that a sex-linked recessive gene hemizygosis in men and homozygosis in women facilitates performance. Assume that the facilitating gene has gene frequency p; then in boys, the phenotypical proportion of good performers on e.g., the RF task should be p, while in girls it should be p^2, an argument which follows from simple genetic assumptions.

With this assumption, it would be expected that boys and girls would have performance scores that would be two value discretely distributed; of course

this is not the case. RF performance is continuously distributed. To account for this fact, the theory makes use of another concept, a mixture of density functions. This notion is easily illustrated. Consider a simple coin flipping experiment. Let the value of a head be 0, and the value of a tail be 5; assume the probability of a head is p, and of a tail is 1-p. To each outcome of the coin is added a randomly chosen number; suppose, for specificity, that the random number is selected from a table of normal random numbers, mean zero, variance one. If a tail is observed, record the value 5 plus the random number .319 or 5.319; if a head is observed, record 0 plus a random component, say +1.005, or 0 + 1.005. A histogram of repeated coin tossings would generate a pair of normal-like distributions with two modes: one centered about 0, the other centered about 5. The relative mass about each mode depends on p, termed the mixing proportion. Should the random component be a normal component the distribution is called a two component normal mixture.

It is proposed that the distribution of observed responses for boys and girls on psychological differentiation tasks, as the RF is a two component normal mixture distribution. The relationship between the mixture distribution and the genetic model is that the mixing proportion is assumed to be the gene frequency parameter. Thus in boys the mixing parameter is p, while in girls the mixing parameter is p^2.

While such a notion has been suggested before for some so called "spatial" tasks (e.g., Bock & Kolakowski, 1973) there has to date been no attempt to utilize the idea in any thorough going way or to test, in data, the plausibility of a mixture model.

While it would take more space to thoroughly explicate the model than is allowed for this submission, it is possible to give the reader an idea of how the theory meets data, and the nature of the data that will be presented.

First, the model predicts that the distribution of boys and girls error responses on the RF task is a mixture of normals model. Data collected years ago by Oltman (1968) provide evidence on the matter. His grouped data for 80 college age boys are presented in the attached figure. First, the data are far from normal; a chi squared goodness of fit to a normal model easily rejects normality. Secondly, using the EM algorithm (Aitkin & Wilson, 1980) the best fitting mixture of normals model is sketched over the grouped data histogram. The normal mixture fits extremely well; the goodness of fit chi squared is 3.6, with 3 degrees of freedom, the fit is quite good $.10 < p < .25$. The estimates of the parameter values are given on the figure; the estimate of the mixing proportion is .85. For Oltman's (1968) 83 girls the fit is even better; the mixing proportion is .79; from the theory it might be expected to be $.85^2 = .72$, so this estimate of .79 is close.

By the use of a learning parameter, the theory specifies that the expression of the facilitating recessive gene is not fully manifested until adolescence; the empirical implications of this development are that while a mixture of normals model should fit RF data for different aged children the differences in the magnitudes of the mixing parameters for boys, and girls should be less for younger than for older subjects. The intuition behind for this expectation is as follows: let the gene frequency parameters be p for boys, p^2 for girls; the differences between the parameters is simply $p - p^2$. Now consider a growth parameter s, $0 < s < 1$; s approaches 1 with increasing age and is 1 in adolescence; this growth parameter is assumed to operation on the proportions p and p^2 in the multiplicative way such that for boys the mixing proportion is sp at each age, where s is small for young children, and $s = 1$ for adolescents; similarly, sp^2 is the mixing proportion for girls. Note that the difference $sp - sp^2$ is less than

$p - p^2$ unless $s = 1$.

Witkin et al. (1954) RF grouped data were utilized to test this prediction, although the sample sizes at each of the ages 8, 10, 13, 15 and 17 were small. In general, the resulting findings can be summarized as follows: i) A mixture model fits the data at each age, and generally quite well; a conventional normal model is not a satisfactory fit to the data. ii) In general, the differences between mixing proportions for the two sexes were in keeping with the theory.

Finally, differences in cross-cultural data can be accounted for simply by assuming that the gene frequency (and mixing) parameter p in boys and p^2 in girls is different for certain different cultures. This is true, e.g., in color blindness data (Post, 1962) known to be sex-linked. It would be expected that sex differences would be most likely to be in evidence in cultures where p is largest, since $p - p^2$ is largest for $p = 1/2$, and is smaller for decreasing values of p. Thus, although the theory predicts that there will be sex differences in each culture, it is argued that unless sample sizes are huge, if p is small, then differences between the sexes will not be found. Cross-cultural RF will be presented (if there is time) which suggest that underlying gene frequencies are different for different cultures. These findings are from unpublished data which the author now has, and are based on data from the Philippines, India, and the US.

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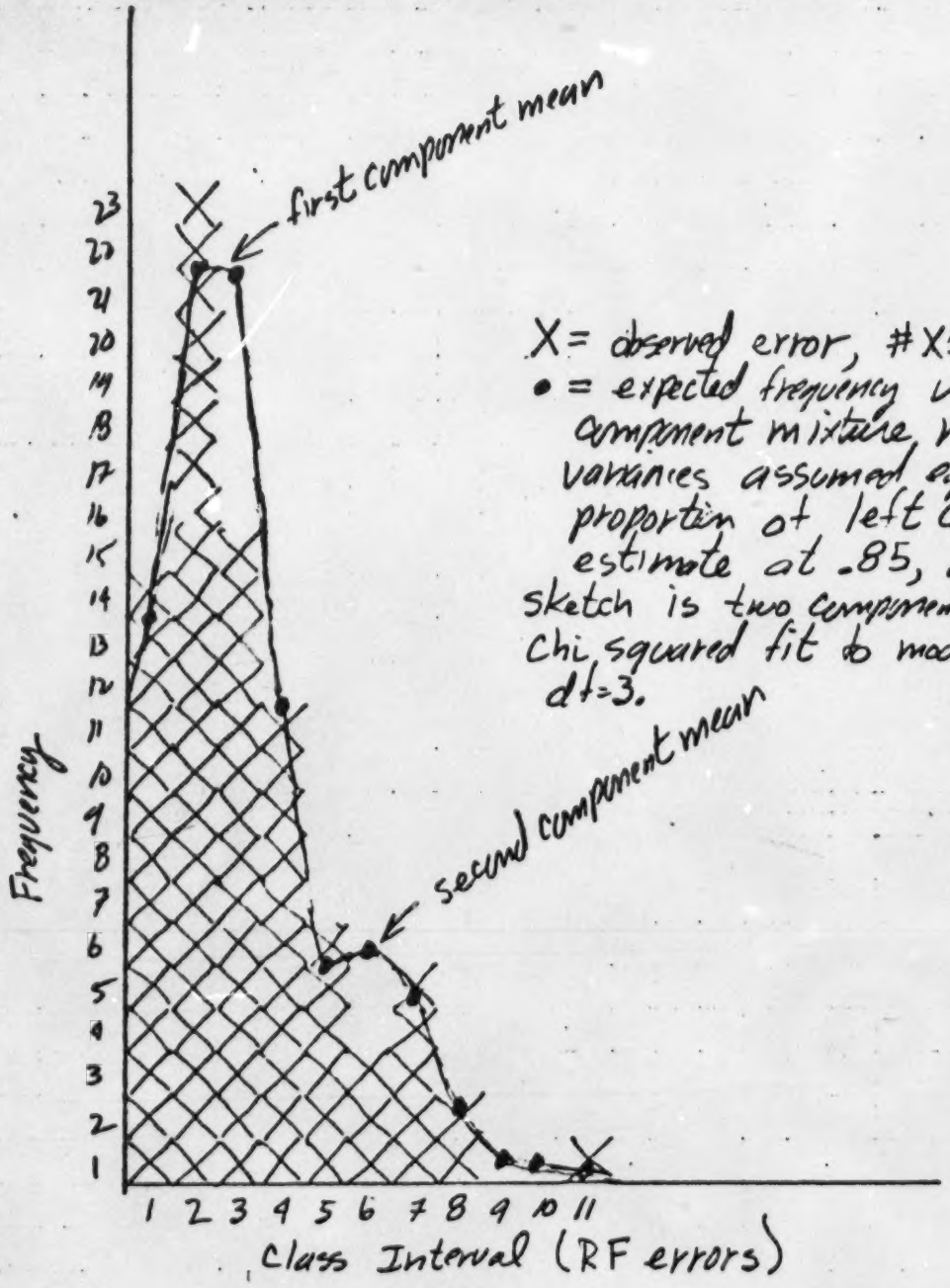

X = observed error, # Xs = 80 = N
• = expected frequency under two component mixture model, variances assumed equal. Mixing proportion of left component is estimate at .85, of right .15.
Sketch is two component normal.
Chi squared fit to model, 3.6, .05 < p < .25, df = 3.

Oltman's (1969) standard rod-frame data, N = 80 College men.